WP4 The landscape of STEAM practices

Deliverable 4.4 Report on lessons learnt

Deliverable 4.4

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Revision History

Revision	Date	Author	Organisation	Description
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Abstract

This final report for the "The Landscape of STEAM Practices" work package (WP4) provides a comprehensive overview of the concepts and findings developed since the project's inception to analyse STEAM practices. Key notions such as the socio-economic criteria (D2.1), conceptual framework (D2.2), the STEAM criteria (D4.1), and the real-life use cases (D4.3) are re-introduced to lay the foundation for the subsequent analysis. As these notions have been extensively covered in previous project reports, they will be presented concisely here with references to the relevant deliverables.

We present an update on the survey results launched as part of T4.2, building on the preliminary findings reported in D4.2. The outcomes of the workshop on STEAM practices are detailed, including selected radar charts and the interactive map of practices now available on the project website. This map presents the complete set of diagrams created until now.

Additionally, this deliverable contains the Evaluation framework for STEAM practice. We discuss the results of the workshops aimed to highlight limitations and fill the gaps of the pre-established criteria and the evaluation framework. They helped produce guidelines to ease the use of criteria and characteristics that delineate the boundaries between effective and less-effective STEAM practices. The report concludes with a section centred on lessons learnt, synthesising the key insights and takeaways from this deliverable.

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1. Introduction

1.1 About RoadSTEAMer

The overall aim of the project is to develop a STEAM roadmap for science education in Horizon Europe, i.e. a plan of action that will provide guidance to EU's key funding programme for research and innovation on how to encourage more interest in STEM through the use of artistic approaches, involving creative thinking and applied arts (the "A" in 'STEAM').

The consortium aims to provide Europe with this roadmap, through:

- Collaboration and co-creation with the stakeholder communities of science education, research, innovation and creativity, through intensive exchange, dialogue and mutual learning among them which will produce better knowledge and shared understandings of the relevant opportunities, challenges and needs.
- A bottom-up approach emphasising educational practice and practitioners' agency rather than high-level conceptualizations of STEAM and generic top-down plans (in reality often just vague statements of intention) for its adoption in science education.
- A specific focus on ways to leverage the power of STEAM approaches, as manifested through exemplary cases and best practices, so as to enable a bridging of open science and open schooling which can catalyse an increased impact for science education as a crucial tool for addressing Europe's current scientific and societal challenges.

1.2 About this deliverable

This report follows three previous deliverables that began outlining the landscape of STEAM practices in Europe. These initial efforts were based on carefully established criteria derived from a thorough literature review. Participatory workshops followed that gathered practitioners' input on their application in various educational contexts.

The current report updates the statistical results presented in Deliverable 4.2. Data collection continued beyond the submission of that report, significantly increasing the number of practices that responded (from 30 to 68). The workshops held between May and July 2024 enabled us to:

- Collaboratively construct radar diagrams for a large number of practices.
- Finalise the evaluation framework.
- Establish guidelines and characteristics of effective and less-effective practices.
- Gain necessary perspective on the work conducted so far regarding the external application of our project's results.

This report aims to provide a comprehensive update and synthesis of the progress made in mapping and analysing STEAM practices, offering valuable insights and tools for the needs of the roadmap.

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2. Previous results

This report is part of a series of deliverables that have examined various aspects of STEAM education, including socio-economic contexts, criteria for evaluating practices, and their application in real-world settings. This section presents a summary of these previous findings. For more detailed information and insights into the methodologies used, please refer to the respective deliverables.

2.1 Socioeconomic context

With the findings collected in D2.1 - Socio-economic context and relevant needs (Unterfrauner et al., 2023), Road-STEAMer explored wider socio-economic contexts and needs for STEAM education in Europe. These efforts included societal needs, the need for inclusion and diversity, fostering interest in STEAM subjects, and related career choices. Based on a thematic literature review and inputs from a co-creation workshop in January 2023, this analysis provided insights and preliminary recommendations on priority areas. The identified needs/recommendations are presented in Table 1:

Need	Proposed recommendations
A science literate European society to ensure that younger generations have the necessary skills to make informed decisions, critically evaluate claims, and understand scientific knowledge	Promoting interest in science by focusing on societal challenges and real-world problems; developing digital literacies beyond computer science; promoting attitudes towards STEAM approaches and solving imbalance of financial supports for 'Arts' within STEAM education; and better connection between the needs of the labour market and lifelong learning
Increase the uptake of science careers	Increasing the level of research on STEAM education effectiveness; making science learning inclusive and appealing; communicating to schools and teachers the values of the STEAM approach; exposing students to science careers from the early years; underling the value of STEAM approach supporting young people to bring these subjects together; and a holistic and subject integrative view
Alignment of industry and societal needs with education (including both 'technical' and 'soft' STEAM-related skills)	Implementing open schooling and other real-world approaches, supporting entrepreneurship and self-employment; promoting multidisciplinary and interdisciplinary project
Increasing diversity in STEAM to move towards greater social justice, offering more opportunities to currently underrepresented groups, and benefitting from their perspective	Affecting structural changes; addressing gaps in abstract thinking/maths from the primary school years; re-shaping role models to define identities and change culture; analysing impact of national differences in school systems; performing more research on moderating factors and career paths to optimise policies

Table 1: Summary of the recommendations based on Socio-economic context and relevant needs

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The STEAM approach holds great promise in addressing contemporary challenges, including the need for improved digital and scientific literacy (Zen (1990); Pellaud et al. (2021), Tasquier et al. (2022))., increased inclusivity in scientific fields (Allen-Handy et al. (2021), Saint-Denis (2021),), and equipping individuals with skills to confront global issues like climate change and inequalities (European Commission. Joint Research Centre. (2020), Das (2020)).

However, the current state of the field suggests that we have as yet insufficient knowledge about understanding the effectiveness of STEAM in meeting these challenges (Alexopoulos et al. (2021), Ng & Fergusson (2020)). Key areas requiring further study include disentangling the impact of arts integration from open and collaborative teaching practices and assessing the influence of contextual factors like socio-economic background, ethnicity, age, cultural context, media influence, and personal differences.

For more details, please see deliverable 2.1 “*Socio-economic context and relevant needs”*.

2.2 STEAM criteria

To identify key criteria to be used in analysing STEAM practices, the University of Exeter team conducted a review of literature focused on studies of STEAM practices with respect to our focus areas, namely open science-open schooling, the role of the Arts, the boundary between secondary and tertiary education, and the interaction between STEAM education and the real world (Chappell et al, 2023). They analysed cases and practices suggested by the consortium, who all contributed a wealth of knowledge and experiences. They used a thematic analysis to synthesise this information and sense-checked and revised it using the Road-STEAMer co-creation methodology to lead to a robust and relevant set of criteria. More details about the process that led to these criteria can be found in deliverable 4.1 “*Research Framework*”. The following criteria emerged as essential dimensions for analysing and understanding STEAM practices within our project:

➢ **Collaboration**: Within STEAM practices, collaboration and relationality revolve around fostering meaningful connections among various stakeholders (Colucci-Gray et al. (2017)). These stakeholders encompass not only teachers and students but also external partners, local communities, educational stakeholders, and local citizens. Mechanisms facilitating collaboration include acceptance, technology integration, game-based learning, and effective communication (Columbano et al. (2021)). Specific art forms, such as music, may serve as catalysts for collaboration. Teachers play a pivotal role, adopting roles as facilitators, advisors, counsellors, and guides, focusing on problem-solving, authentic tasks, student choice, and technology integration in classroom environments. They collaborate not only with students but also with their fellow educators, emphasising dialogue and the management of classroom environments to promote disciplinary inter-relationships. Various terminologies, including collaboration, group working, teamwork, and interaction, are employed to describe this criterion, often regarded as a 21st-century skill (Bautista (2021)). Some advocate viewing collaboration and relationality as integral components of a broader STEAM culture featuring multi-modality. Expanding this perspective, proponents within the posthuman paradigm extend collaboration and relationality to include not just

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human interactions but also interactions with the environment and the broader planet, aligning with the need to address challenges in the Anthropocene era (Guyotte (2020).

➢ **Disciplinary inter-relationships**: This criterion in STEAM practices encompasses several facets. It may involve the inclusion of multiple disciplines within STEAM, allowing for cross-disciplinary exploration and knowledge transfer. It can also manifest as the integration of arts into science, technology, engineering, and mathematics (STEM) curricula, emphasising an interdisciplinary approach (Liu et al. (2022)). More elaborately, it involves forging new connections between subjects or skill areas, fostering interaction between different disciplines, and enabling students to transfer knowledge between them in a transdisciplinary approach (Liston et al. (2022)). Students are encouraged to transfer knowledge across disciplines, often in classrooms emphasising problem-solving, authentic tasks, and technology use. STEAM practices value experimental agency, and foster connections between arts and science creativities. Additionally, it contributes to the understanding of disciplinary identities, with personal relevance informing connections between different subjects.

➢ **Thinking-Making-Doing**: This aspect of STEAM underscores the interactive nature of these practices. Various forms of thinking come into play within STEAM, including habits of thinking, systems thinking, critical thinking, creative thinking, and divergent and convergent thinking. Importantly, thinking isn't isolated but is intertwined with a broader set of skills, promoting soft skills and 21st-century skills (Graham (2021)). STEAM practices are closely linked to problem-solving, viewed as a creative, cognitive, and interactive process. These practices emphasise hands-on design, production, and real-world learning, reinforcing that STEAM is not purely academic but also practical. Making and doing are integral components, often associated with the "Makers movement," which values individuals as creators and emphasises students' active, constructive, and critical roles in their learning (Bautista, (2021)). Additionally, the importance of object-based learning, critique, exhibition, and critical making is highlighted, drawing inspiration from signature pedagogies in the arts (Costantino, (2018)). This interconnectedness of thinking, making, and doing within STEAM contributes to a holistic and dynamic learning experience.

➢ **Creativity**: Creativity is a fundamental component of STEAM activities, aligning with broader creativity literature. In STEAM, creativity is associated with innovation and the generation of novel ideas and outcomes. It's also linked to playfulness and the concept of "flow," which can be nurtured through STEAM practices (Dredd et al (2021), Martinez (2017)). Problem-solving and open-ended engagement with problems are facets of creativity within STEAM. Some sources depict creativity as a skill developed through STEAM practices, highlighting its role as both a means and an outcome. Creativity is not confined to thinking but extends to doing, where tools like digital technologies and design thinking are creatively employed. This creative approach aids in making interdisciplinary connections and fostering collaboration. Ultimately, creativity serves as a vital means to support various aspects of STEAM practices and is considered both a process and a product of these practices (SciCulture nd, Martinez (2017)).

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➢ **Real-world Connection:** In STEAM practices, there is a strong emphasis on anchoring learning in real-world contexts (Martinez (2017)). This connection often involves tackling contemporary and complex issues like climate change, aligning with broader EU policies such as the EU Strategy for Enhancing Green Skills (European Commission, 2020). Real-world contexts are intricately linked to problem-solving and inquiry-based learning, providing authenticity and purpose to interdisciplinary connections. The civic space is identified as a valuable real-world context that bridges Higher Education learners with the public. It enables learners to connect their personal meaning-making within and between disciplines to the external context, fostering identity development, including empowering girls to see themselves as change-makers (Wan et al (2020). Entrepreneurship is a recurring theme in both EU and international STEAM projects, serving as a means to establish connections between STEAM activities and real-world contexts.

➢ **Inclusion/Personalisation/Empowerment:** In STEAM, inclusivity takes various forms, stemming from the belief that incorporating the Arts into STEM fosters a wider range of interests and makes STEAM more inclusive than STEM alone (ecraft2Learn (2018)). Acceptance is crucial in designing STEAM activities to ensure all participants, regardless of confidence levels, can fully engage in the process. Inclusion aligns with the theoretical concepts of science capital and identity, where STEAM provides a context for young people to develop their identities and see STEAM as a domain "for them." This active construction of personal meaning in STEAM leads to greater self-efficacy, confidence, and motivation for socioscientific learning, promoting empowerment. STEAM's open-ended activities and real-world contexts further enhance inclusion and empowerment, potentially empowering individuals from underrepresented groups, such as girls, to identify as change-makers (Wan et al (2020)). STEAM's emphasis on personalization and empowerment contributes to a more inclusive and engaged learning environment.

Additionally, it's essential to recognise **"Equity"** as an underlying value that should permeate all STEAM practices and transcend all other core criteria. It emphasises fairness and inclusivity in the design, processes, and outcomes of STEAM education. STEAM is viewed as a resistance to traditional disciplinary approaches, advocating for an ethical stance. This involves breaking down hierarchies between disciplines, recognizing the arts alongside STEM subjects, and ensuring equitable access to resources. Additionally, STEAM often empowers students to take the lead in their learning, promoting a more equitable power dynamic by positioning teachers as facilitators.

While STEAM aspires to produce socially equitable responses to global challenges, empirical evidence for this outcome is currently limited. Notably, the emphasis on equity is more prominent in tertiary-level STEAM practices compared to secondary education, though further exploration is needed. While not identified as standalone criteria, we observed that concepts such as digital technologies, open-ended activities, and problem identification and solving are interwoven throughout and across the key criteria.

The comprehensive understanding of these criteria and their interrelationships have guided our analysis of STEAM practices in the different phases of our project, particularly within the scope of Work Package 4. This structured approach enabled us to explore and analyse

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STEAM practices with depth and precision, contributing valuable insights to the project's overarching goals.

For more references and the detailed study, please see deliverable 4.1 "*Research Framework".*

2.3 Conceptual framework approaches

At the core of the Road-STEAMer conceptual framework is the principle of relationality, emphasising that entities are defined by their relationships with other entities (Spyrou, 2022). This perspective extends Bingham and Sidorkin's idea that "there can be no education without relation" (2004) to a broader understanding of STEAM education. The framework highlights the importance of relations between humans, disciplines, settings, and the real world in STEAM practices.

The D2.2 conceptual framework links STEAM practice aims with observed effects, allowing transfer of best practices across contexts. Four groups of theoretical approaches from the literature were detailed in D2.2: experiential real-world, human psychological and cognitive, social, spatial and material interconnectivity, and cultural and equity.We suggest that within STEAM, these approaches should be viewed/interpreted from an underpinning relational stance.

2.3.1 Experiential real-world interaction approaches

These approaches emphasise active, real-world experiences, particularly for learners. They focus on nuanced, experiential knowledge and interactions. Key theories include:

- **Active Learning (Caratozzolo et al., 2021)**: Engages students in experiential or cognitive activities to foster learning. Learners should actively think to understand and memorise.
- **Aesthetics (Mehta et al., 2019)**: Encourages diverse engagement with arts to integrate aesthetics into STEM learning and teacher development.
- **Constructivism (Domenici, 2022)**: Asserts that "(human) knowledge is acquired through a process of active construction". Effective learning is an active process socially constructed by learners through meaningful, open-ended challenges.
- **Creative Inquiry for Transdisciplinarity (Costantino, 2017)**: An iterative process involving problem definition, multimodal exploration, presentation of ideas with multiple in-process critique and exhibition allowing reframing of the problem.
- **Dewey/Learning Through Experience (Stroud & Baines, 2019)**: Combines education and experience, supporting knowledge construction through observation, knowledge of similar experiment/result, and judgement. Applied in inquiry-based learning integrating arts into STEM.

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2.3.2 Human psychological and cognitive approaches

These approaches are grounded in psychological traditions, focusing on cognitive processes, often articulated through frameworks or processes that involve interaction of individuals/groups with the environment. Key theories include:

- **Bloom's Learning Taxonomy (Del Valle-Morales et al., 2020)**: Categories learning into six cognitive processes: Remember, Understand, Apply, Analyse, Evaluate, Create, aiming to create meaningful STEAM learning experiences.
- **Creative Thinking (Chen & Lo, 2019)**: Involves using subjective perspectives to produce novel and useful innovative products through processes such as Human-centred design.
- **Five Creative Dispositions Model (Harris & de Bruin, 2017)**: Defines creativity as a socially situated learning process with five core dispositions: Inquisitiveness, Imagination, Persistence, Discipline and Collaboration.
- **Flow State (Dredd et al., 2021)**: Describes optimal experience and immersion in tasks, it relies on the way of approaching a problem more than its answer.
- **Resilience (Del Valle-Morales et al., 2020)**: Ability to adapt to a problem. Commonly associated with relationships, identity, power and control, social justice, access to material resources, cohesion, cultural adherence.
- **Resourcefulness (Avendano-Uribe et al., 2022)**: Highlights innovation through internal and external sources.
- **Self-efficacy (Boice et al., 2021; Full et al., 2021)**: Addresses how individuals' beliefs in their success influence engagement and persistence in STEAM activities.
- **Torrance Tests of Creativity (Chang et al., 2019)**: Measures creativity through fluency, flexibility, originality, and elaboration.

2.3.3 Social, spatial and material interconnectivity approaches

These approaches emphasise interconnectivity, considering human beings in relation to various others, including material elements, space, time, and affect. Key theories include:

- **Affirmative Ethics (Guyotte, 2020)**: Views ethics as an ongoing action in which subjects are entangled in social and material relationships, oriented towards an unknown future.
- **Connected Learning (Bass et al., 2016)**: Advocates a sociocultural approach where personal interests are linked to academic and career success through supportive communities.
- **Flow State (Dredd et al., 2021)**: Describes optimal experience and immersion in tasks, it relies on the way of approaching a problem more than its answer.
- **Nexus Theory (Peppler & Wohlwend, 2018)**: Suggests that intersections of different disciplinary practices create transformative new practices.

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- **Slowing (Guyotte, 2020)**: Encourages considering the social and ethical implications of work by slowing down scientific processes. It can apply to STEAM through acknowledgement of an individual's situatedness and his implication in the natural world.
- **Social Network Theory (Boice et al., 2021)**: Focuses on relationships as building blocks of the social world, with emergent patterns of connections among people and groups. It can apply to STEAM in the case of teacher collaboration networks.
- **Social Practice Theory (Quigley et al., 2019)**: Concerned with practice bundles and how practices are reproduced, maintained, and challenged.
- **Space-time and Culture (Davies & Trowsdale, 2021)**: Uses a multicultural lens to understand disciplinary cultures, drawing on semiotic and quantum conceptions of space-time. It can allow teachers to view STEM and arts subjects as equal.
- **Transdisciplinarity/Creativity through Spatiality/Materiality beyond the Human (Chappell et al., in press)**: Advocates for solving complex problems through integrated methodologies from various disciplines, promoting posthuman creativity.

2.3.4 Cultural and Equity approaches

These approaches use cultural theorisations emphasising equity and inclusion, considering collective ideas, customs, and behaviours. Key theories include:

- **Critical Pedagogy (Chung & Li, 2021; Fletcher & Hernandez-Gantes, 2021; Kiyani et al., 2020)**: Views education as a tool for empowerment, enabling learners to undo oppressive structures through social change.
- **Culturally Responsive Pedagogy (DeVito et al., 2020; Kant et al., 2018; Rao et al., 2021)**: Centres on teaching that includes cultural references and respects students' cultural backgrounds, fostering social justice for minority students.
- **Narratives (Avendano-Uribe et al., 2022)**: Involves reshaping narratives to represent diverse perspectives and experiences often missing in mainstream discourse.
- **Identity Theory (Avendano-Uribe et al., 2022; Claville et al., 2019; Full et al., 2021)**: Explores dynamic identity formation through social interactions, focusing on engagement and persistence in STEAM for underrepresented groups.
- **Social Justice Pedagogy (Fletcher & Hernandez-Gantes, 2021)**: Uses “critical pedagogy for emancipatory and participatory instructional strategies” aimed at positive social change.
- **Space-Time and Culture (Davies & Trowsdale, 2021)**: Uses a multicultural lens to understand disciplinary cultures, drawing on semiotic and quantum conceptions of space-time. It can allow teachers to view STEM and arts subjects as equal.

The articulation between approaches and criteria is represented in Figure 1. These approaches will be very useful for the roadmap helping us understand how they can address socio economic challenges exposed in D 2.1 and allowing an in depth analysis of practices in different contexts to transfer best of them from a specific context to another.

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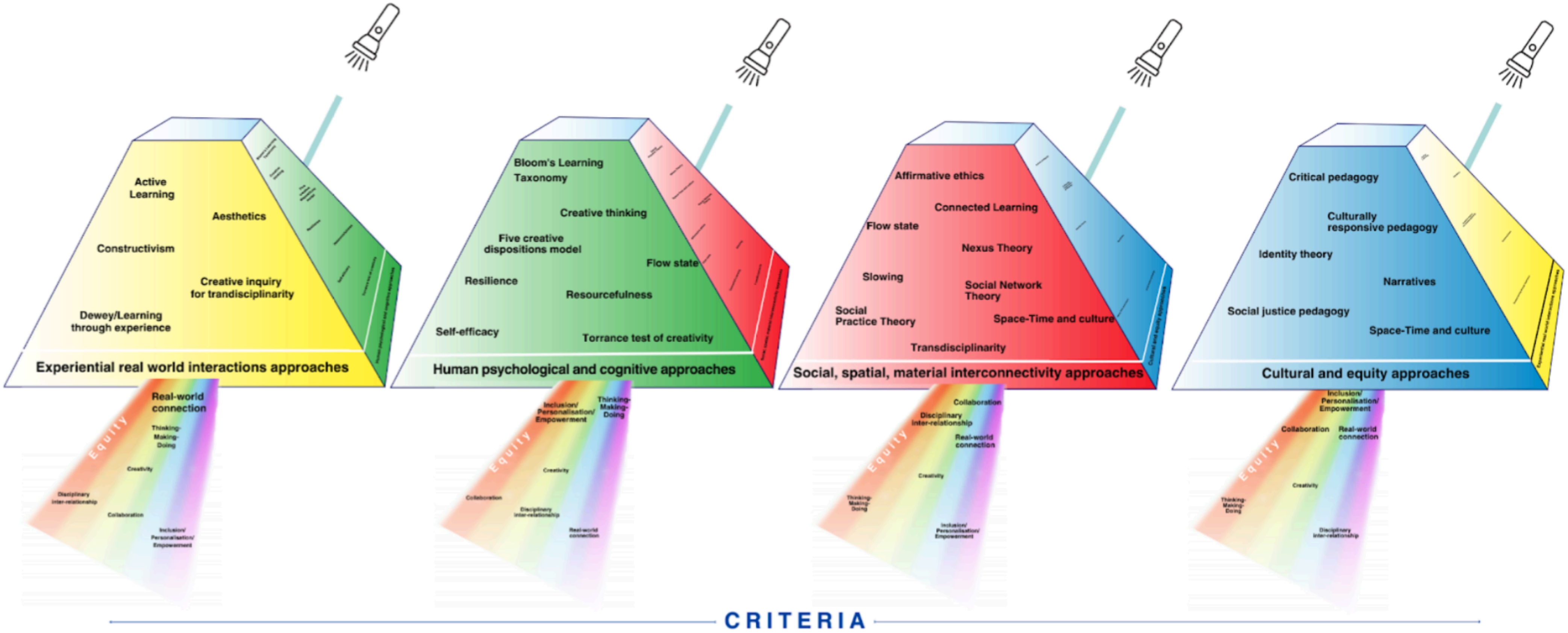

Figure 1: Each approach's pyramid diffracting the criteria showing a different manifestation of the criteria in relation to that approach

A more detailed infographic is available on our website (https://www.road-steamer.eu/). For more information, please see deliverable 2.2 "*RoadSTEAMer conceptual framework*".

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2.4 STEAM Real-life use cases

In analysing STEAM practices as real-life use cases (RLUC), we focused on the development and implementation of STEAM methodologies in educational settings beyond traditional classrooms. This investigation is based on the six STEAM criteria established in our project, alongside equity as an underpinning value. Key considerations included:

- **Necessary Conditions for Meaningful Delivery:** Effective STEAM practices require conditions such as access to resources, conducive learning environments, and supportive institutional frameworks that foster authentic learning experiences.
- **Teacher and Facilitator Skills:** Successful STEAM implementation depends on educators' skills in promoting interdisciplinary thinking, collaborative problem-solving, and inquiry-based learning, beyond subject matter expertise.
- **Skills Addressed:** STEAM aims to develop students' disciplinary knowledge and competencies like creativity, critical thinking, communication, and interdisciplinary integration. Our inquiry examines how well STEAM initiatives address these skills.
- **Incorporation of the Arts:** The arts play a crucial role in STEAM by offering unique perspectives and methodologies. We investigate whether the arts act as supplemental elements, equal partners, or tools for enhancing scientific inquiry and interdisciplinary connections.
- **Real-World Connection:** STEAM practices bridge theoretical learning with real-world application, contextualising scientific concepts within societal challenges like the climate crisis. This connection elevates STEAM from learning activities to practical use-case scenarios, empowering students to enact meaningful change.

By examining these dimensions, D4.3 report provided insights into STEAM practices, offering pathways for developing innovative pedagogies that nurture critical thinkers, problem solvers, and changemakers.

The first workshop facilitated rich dialogue and collaborative exploration around four key elements shaping the delivery of STEAM activities:

- **World Challenges Addressed:** Participants identified global issues like political violence, extremism, climate change, and sustainable development as catalysts for meaningful inquiry and action through STEAM.
- **Approaches Employed:** Discussions covered diverse pedagogical methods such as open schooling, living labs, problem-based learning, and hackathons, evaluating their effectiveness in promoting interdisciplinary collaboration and innovation.
- **Skills Addressed:** Participants highlighted the wide range of skills cultivated through RLUC practices, including art-related skills, computer science and digital literacy, making skills, design thinking, intercultural competence, and essential soft skills.
- **Delivery Settings:** The workshop emphasised the impact of various delivery settings, from traditional classrooms to community initiatives and digital platforms, on the effectiveness of STEAM interventions.

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The second workshop (in-person) was conducted in the framework of the OTTER project "Beyond the classroom: rethinking STEAM education" final event which took place in February 2024. It followed a "World café" format to present findings from Road-STEAMer's research phase, focusing on the defined STEAM criteria and their interaction with socio-economic contexts. It transitioned into a practical exploration of STEAM practices. Participants engaged with real-life examples to assess the effectiveness of these practices in addressing authentic challenges. Key areas of focus included:

- Addressing real-world challenges directly, highlighting the practical relevance and societal impact of STEAM education.
- Emphasising the skills and competencies required of teacher-facilitators to guide student learning effectively.
- Examining the diverse skill sets developed among students through STEAM engagement, encompassing domain-specific knowledge, critical thinking, collaboration, and problem-solving skills.

By grounding theoretical insights with practical examples, the workshop aimed to deepen participants' understanding of how STEAM education can empower students to actively participate in a dynamic global environment. Additionally, participants highlighted the advantages of incorporating Outdoor Education Elements in STEAM practices, enhancing local relevance, student motivation, and ownership in addressing community challenges.

The third workshop took place in the context of the "Learning Science through Theatre" initiative in Greece and its final event, in March 2024. It was delivered online with 20 teachers, school advisors, science theatre experts and STEAM researchers. They reflected on their own practices using the Road-STEAMer criteria, focusing on societal challenges, skills needed and addressed, and delivery settings. Three major insights emerged:

- **Addressing Societal Challenges**: There is a significant difference between STEAM projects that integrate stakeholder expertise (e.g., parents, museums, research institutions, industry) in co-creation activities to address societal challenges (e.g., climate change, biodiversity) and those that merely add an engagement activity at the end, such as a presentation to parents or local communities.
- **Teacher Motivation and Skills**: Innovative teachers who go beyond prescribed curricula in STEAM projects do so not to stand out but because innovation, creativity, and sensitivity to societal challenges are intrinsic to their professional identity. These attributes are central to their role, rather than additional skills they choose to exercise.
- **Integration of the Arts in STEAM**: There is a misconception that adding a small artistic activity at the end of a STEM project transforms it into STEAM. Proper integration of the arts requires them to be a fundamental aspect of the project from the beginning. This integration is essential for teaching, learning, and reflecting on science and demands relevant skills and resources, which are often lacking in underfunded educational contexts.

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The fourth online participative workshop took place in April 2024. The event was conducted with Polish STEAM practitioners, researchers and teachers, gathered through the network provided by the Copernicus Science Centre (one of the two affiliated entities of ECSITE in the Road-STEAMer project). The specific focus was on gaining feedback on the application of such criteria on the ground.

After a brief project introduction, participants quickly identified that the STEAM criteria matched their activities well. Post-COVID-19, there was a strong emphasis on personalisation and collaboration. Participants noted that activities became more learner-centric, fostering responsibility and individuality. Additionally, the willingness to socialise and work in groups increased, exemplified by science competitions like designing satellite prototypes or rovers, which connected theoretical knowledge to real-world challenges.

Participants discussed the necessary skills for teachers and STEAM practitioners to deliver high-quality activities. They emphasised the need for teachers to be skilled facilitators, guiding discussions and fostering creativity, with an open-minded approach to emerging topics like Artificial Intelligence (AI). The discussions highlighted two risks associated with innovative teaching methods:

- **Conceptual risk**: Students might undermine a teacher’s authority when exploring new technologies they are more familiar with.
- **Material risk**: Teachers in public institutions might overuse limited, expensive equipment, especially in resource-constrained schools.

The fifth and final online workshop on RLUC took place in early May, 2024. Aiming at inquiring STEAM practitioners and researchers in Ukraine, the event was co-organised by the Junior Academy of Science in Ukraine (also an affiliated entity of ECSITE within the Road-STEAMer project) which mobilised their network and gathered 20 participants including chief, senior and fellow researchers, professors of science education, directors and deputy directors of science centres, practitioners and teachers. The major focus was to analyse how STEAM practice was delivered in emergency settings such as the current context of Ukraine. While the majority accepted the 6+1 criteria, some suggested adding elements like ‘Task-Commitment,’ ensuring activities have logical conclusions.

Key insights included:

- **Criteria Flexibility**: Not all STEAM activities encompass every criterion, especially in subjects like Mathematics, which may lack a real-world connection but promote creativity through puzzle-based learning.
- **Emergency Settings**: Initial wartime activities included puzzles and gamified learning to distract pupils, while current efforts use AI to improve morale and digital tools to merge arts and science.
- **Innovative Practices**: Examples included using AI to analyse plant photos and digital apps for science-based drawings. Broader initiatives like Space Living Labs promoted interdisciplinary learning and inclusion.

Participants expressed a strong focus on achievements, innovative practices, and future plans for STEAM rather than dwelling on wartime challenges.

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3. STEAM survey update

This section of the report presents updated results from a questionnaire initially introduced in Deliverable D4.2. To achieve more representative results, the consortium continued to collect responses until June 2024. The updated statistical analysis now includes data from 67 practices, compared to the 30 practices covered in D4.2. In this section, we will provide an overview of the updated findings, reflecting the extended data collection efforts. We will not present again the data collection and processing methodologies, which have been thoroughly detailed in Deliverable D4.2 (see D4.2 for further details). Finally, we will introduce radar charts produced using the second part of the survey, focused on criteria analysis.

In the following part the diagrams and numbers presented exclusively incorporate the 67 fully completed questionnaires collected and do not include data from desk research. Due to the limited number of responses, the statistics presented in this report may not be fully representative of the broad spectrum of STEAM practices. As such, the findings should be interpreted with caution although they are more accurate than those presented in D4.2. The diagrams presented here will not be systematically detailed, and only notable changes compared to the preliminary results will be commented on.

3.1 General insights

The results in Figure 2 have not changed significantly. However, it is worth noting that the proportion of practices collaborating with universities is greater than those involving the business sector.

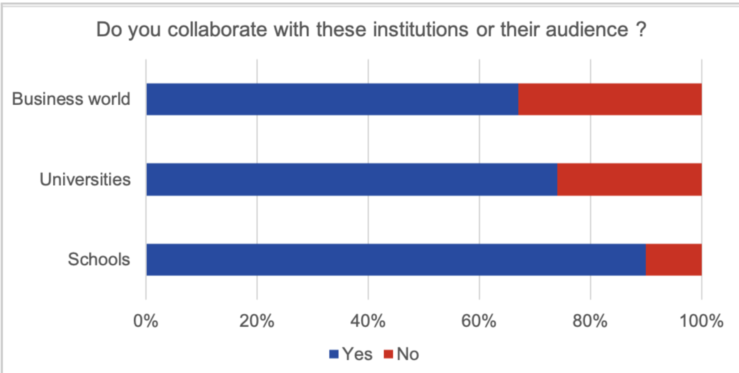

Figure 2: Percentage of collaboration with different institutions

Notably, among practices collaborating with universities, the vast majority engage with the research community to promote knowledge sharing with society rather than focusing on higher education. Only 23% (12 practices) explicitly involve tertiary students, confirming a lack of offerings at this level. Half of university collaborations take place at a European scale.

Contrary to initial statements, European projects seem to account for 39% of practices, national projects for 19%, and local projects for 28%. It should be noted that there may be an overrepresentation of European projects due to the consortium members' involvement in them. Practices conducted at the local level report having access to appropriate funding in 67% of cases, compared to 50% at the national level and 48% at the European level.

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The European Commission established 8 key competences encouraging peer learning and exchange of good practices. Figure 3 presents the competences most frequently developed by the considered practices, with each practice selecting up to three skills of the eight.

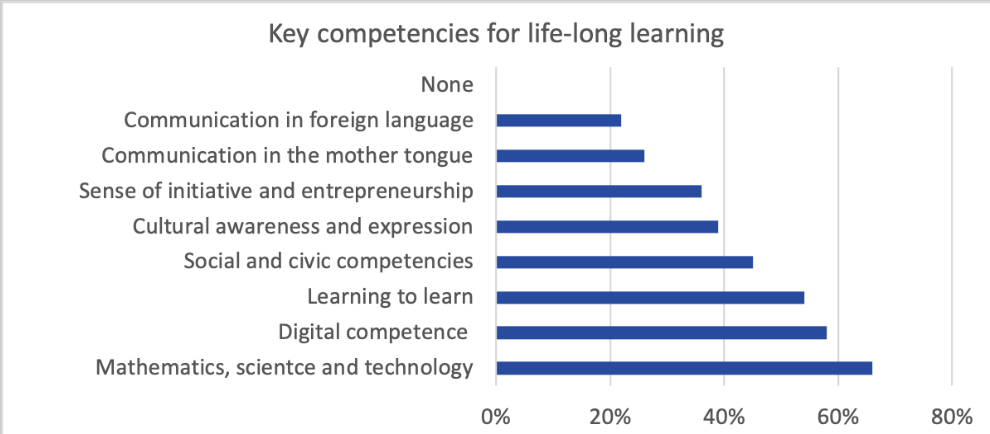

Figure 3: Key competencies for life-long learning most addressed in practices

3.2 Socioeconomic insights

The societal challenges mainly addressed in practices vary depending on the scale of the practice, as shown in Figure 4. Future employment being the main European challenge, and gender's equity the main local challenge. Racism and sexism are very rarely addressed (around 8% and 6% respectively).

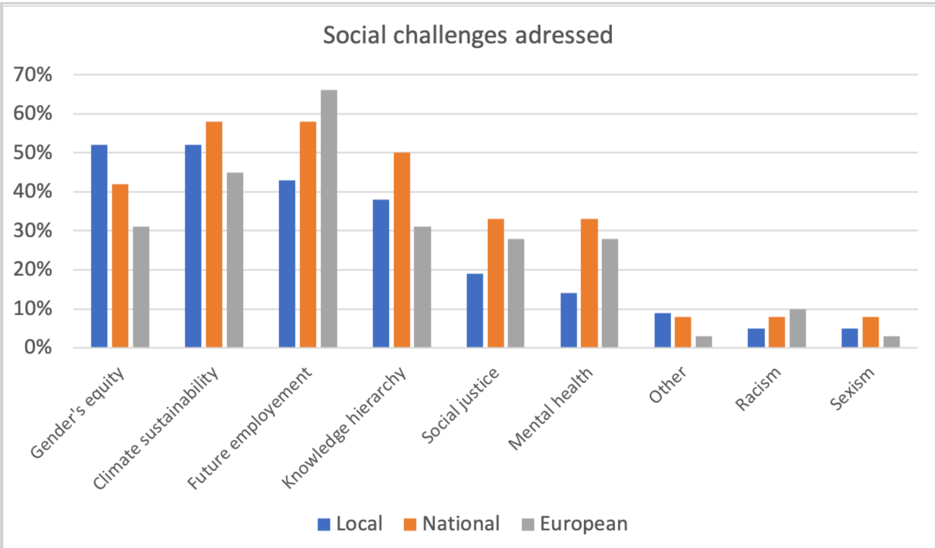

Figure 4: Percentage of practices addressing specific social challenges considering their scale

The proportion of activities involved in open schooling or open science remains similar as shown (respectively 72% and 58%). Only 11% are involved in none.

The socioeconomic aspects including specific policies to reach underserved minorities or potential barriers for participation are shown in figures 5 and 6 and didn't significantly evolve.

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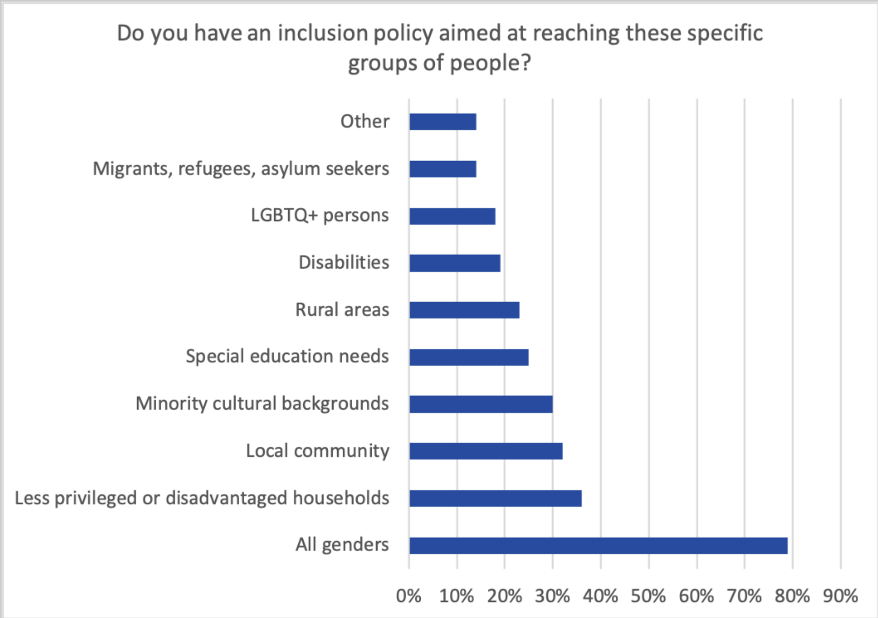

Figure 5: Percentage of activities having inclusion policies for reaching specific groups of peoples

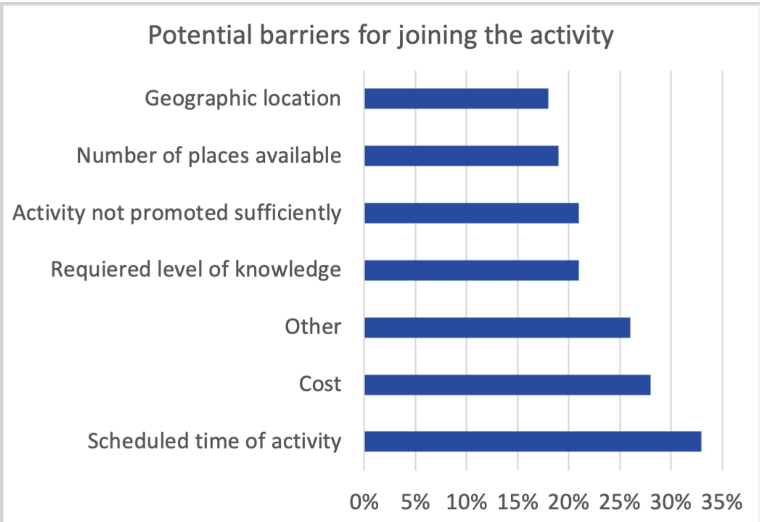

Figure 6: Percentage of the potential barriers for joining the activities

The dataset can be found in open access on Zenodo (https://zenodo.org/records/13371686).

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3.3 Radar charts workshop

3.3.1 The workshop

At the consortium meeting held in Exeter in May 2024, the first workshop of task 4.4 was organised to construct radar charts for over 54 practices. Twenty participants contributed to this collective effort, using survey responses focused on socioeconomic aspects and criteria, synthesised into a one-page document (see annexe 1). Each practice description included a website link if available.

Some practices were excluded prior to the workshop for not aligning with the focus of RoadSTEAMer, while others with less clear relevance were retained for evaluation. Participants were informed that some practices might be off-topic and were invited to indicate this in their comments to ensure such practices were excluded from our study.

Before the workshop, participants had reviewed and individually rated the practices to facilitate smoother discussions. During the workshop, they were divided into groups of 3 or 4, with each group reviewing and rating 8 practices based on the seven pre-established criteria (on a scale of 1 to 10). Participants then had a few minutes to discuss each practice and agree on common ratings. The ratings from different groups were harmonised to achieve an overall average between 6.5 and 7.5 for each group, considering only practices recognised as STEAM.

3.3.2 Results and feedback

Radar charts were created for each evaluated practice to visually summarise scores. An example chart is presented below (see Figure 7) and charts of some highly effective practices are shown in section 4.3. All can be found on the interactive map on the project website, introduced in the next section.

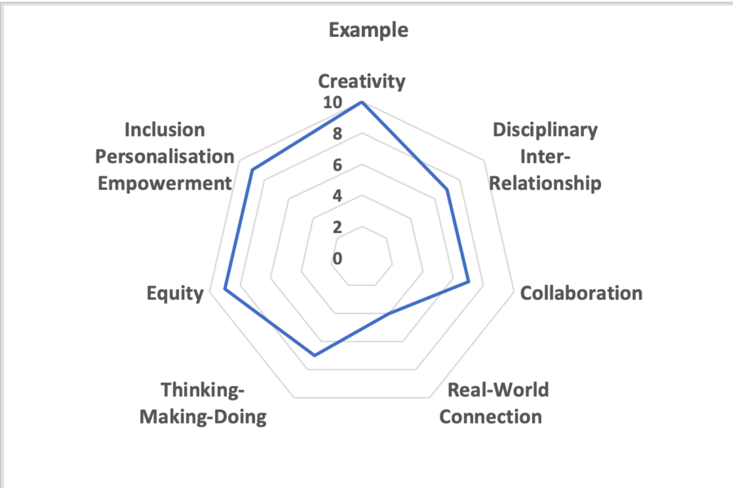

Figure 7: Radar chart template

This graphic representation provides a clear, synthetic presentation of the 7 criteria in a single figure. It also allows for a qualitative comparison of two practice criteria by displaying the same information in a comparable manner.

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Participants generally appreciated the collaborative and structured approach of the workshop. The preliminary individual exercise to familiarise participants with the practices and criteria was highlighted as beneficial. Group discussions were lively and insightful, often leading to re-evaluations and deeper understanding of the practices. Some partners noted that discussing and revising the ID cards as a group offered new perspectives. The production of radar charts was valued as it facilitated visual representation of the criteria.

3.3.3 Online interactive map

An [Interactive map of STEAM practices] has been added on the project's website to share the survey results publicly. It is displayed on Figure 8.

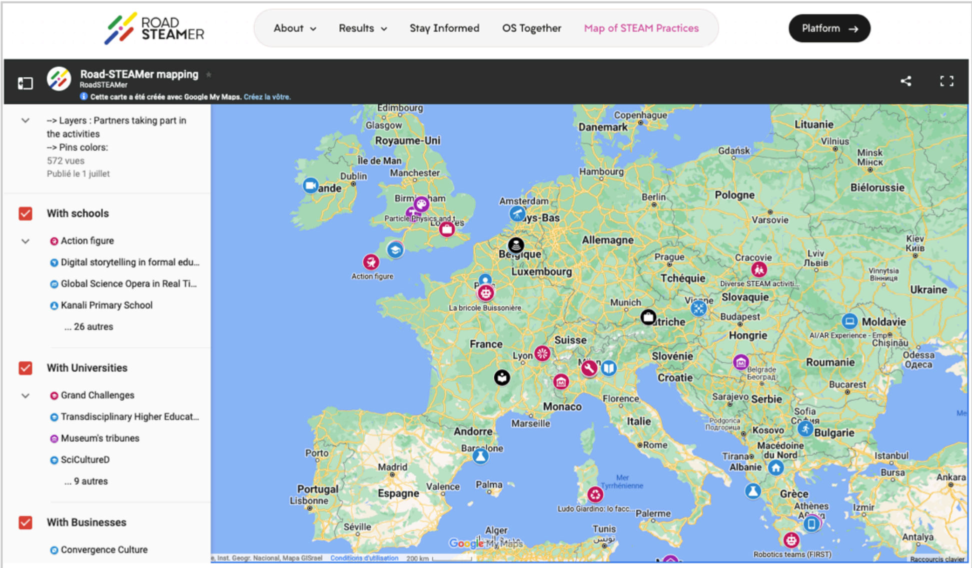

Figure 8: RoadSTEAMer's Interactive Map of STEAM Practices

At the time of this report's publication, a total of 70 practices were included. Additional practices will continue to be added until the end of the project.

This mapping aims to foster practitioner engagement in the project. It serves as a visibility tool for various existing projects and as a potential source of inspiration for those wishing to implement STEAM practices in diverse educational settings.

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4. Evaluation framework feedback

This section first presents feedback received on potential improvements to the criteria and the collective radar chart workshop. Following this, we discuss the two online workshops from Task 4.4, which brought together consortium members, particularly participants from WPs 2, 3, 4, and 5. The aim of these workshops was to address gaps in the evaluation framework identified after the initial workshop, including providing guidelines to help users in scoring the criteria, establishing clear boundaries between effective and less-effective STEAM practices, and selecting exemplary practices. Additionally, these workshops allowed for the collection of acknowledgments or warnings about the framework's limitations and its application for future users.

4.1 First workshop: around criteria and radar chart

The following feedback has been gathered through an online collective document filled in individually by every participant during the weeks following Exeter workshop.

4.1.1 The 7 criteria

The criteria were seen as appropriate and grounded in practical realities accordingly with the RLUCs results. They were considered relevant and evaluable, with no significant criteria missing.

Some partners felt that the 6+1 criteria might be too many and that not all criteria were applicable to every practice. It should be noted that this fact is recognised by the consortium: not all the criteria need to be represented in each practice, it is a broad selection and a very effective STEAM practice may present only part of them.

The subjectivity of some criteria was a concern, and standardising the assessment process a potential solution; However, a degree of subjectivity is inevitable when analysing such a variety of different practices. The best solution is likely to rely on the honesty of those providing the information as well as the evaluators. The collective scoring is another barrier to this subjectivity. Finally, conducting it dishonestly would be of very little benefit to users.

It was highlighted that criteria should be introduced and explained in detail before the exercise to ensure clarity. Providing examples for each criteria, especially for external users, could improve understanding and application. Establishing "cut-offs" points to determine when a practice can be considered as effective or less-effective is needed to help define STEAM boundaries.

4.1.2 The radar charts workshop

Several areas for improvement were identified:

- Participants recommended having someone familiar with the project present during discussions to provide additional clarifications.
- Examples of low and high scores for each criterion could be useful, especially for those not familiar with the project.

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Some participants mentioned the potential benefit of ranking practices instead of assigning numerical values to reduce subjectivity. Finally, ensuring that individuals responsible for filling in the ID cards are well-informed about the criteria in advance could enhance the quality of information provided.

These considerations are relevant and partly depend on the discretion of individuals who wish to use the evaluation tool proposed here. Regarding boundaries and examples, the following two sections aim to address these needs.

4.2 Second workshop: production of criteria guidelines

The second workshop was held online on the 3rd of July 2024. The mural used is shown in Figure 9.

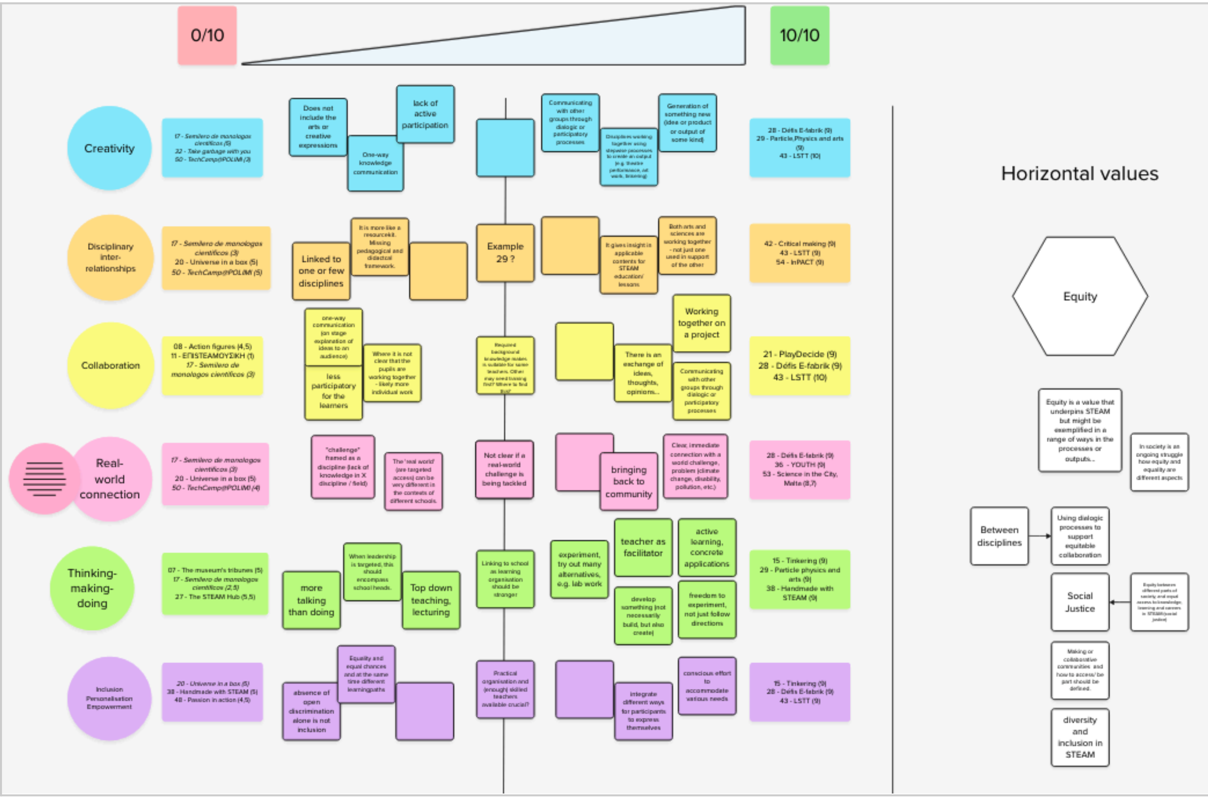

Figure 9: Mural produced after the second workshop of T4.4

This collaborative workshop led to a set of guidelines to help future users of the RoadSTEAMer evaluation framework. Table 2 presents guidelines linked with lowest and highest grades for each criteria. They can be used while rating practices.

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Criteria	Lowest scores	Highest scores
Creativity	- Does not include any creative expressions or arts - One-way knowledge communication - Lack of active participation	- Communicating with others (through dialogue or participation processes) - Disciplines working together using stepwise processes to create an output (e.g. theatre performance, art work, tinkering…) - Generation of something new (idea or product or output of some kind)
Disciplinary inter-relationship	- Linked to one or few disciplines - Missing pedagogical and didactic framework (like a resource kit of unrelated tools)	- Several disciplines are involved in an equal way - Both arts and sciences are working together - not just one used in support of the other
Collaboration	- One-way communication - No participatory aspect for participants - Participants are making individual work	- There is an exchange of ideas, thoughts, opinions... - Communication with other groups through dialogic or participatory processes
Real-world connection	- Placing the disciplines as challenges themselves - Disconnection between the practice and real-world	- Linking the practice to local community - Clear, immediate connection with a world challenge, problem (climate change, disability, pollution, etc.)
Thinking-making-doing	- One-way knowledge transmission without practical aspects	- Experimenting, trying out many alternatives, e.g. lab work and prototyping - Developing something (not necessarily build, but also create) - Active learning with concrete applications - Participants have the freedom to experiment, not just follow directions
Inclusion Personalisation Empowerment	- Absence of open discrimination alone is not inclusion - Obvious different learning paths	- Integrate different ways for participants to express themselves equally - Conscious effort to accommodate various needs

Table 2: Guidelines for lowest and highest scores for STEAM criteria

The equity criteria have been approached differently due to its multifaceted nature within STEAM practices, it is referred to as a "horizontal value." For example, when considering interdisciplinary collaboration, the goal is to integrate and use different disciplines cohesively rather than in parallel. This approach is seen as a positive characteristic. On the other hand, when focusing on social justice, equity between various societal groups is highlighted by promoting equal access to knowledge, learning, and STEAM careers. Therefore, practices that incorporate these aspects should be recognised as fostering equity.

Given the complexity and variability of equity, its evaluation is left flexible. To make it, users should refer to the definition provided in D4.1 and summarised in section 2.2 of this deliverable. It is essential to keep in mind the diverse dimensions of equity that are encompassed.

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4.3 Last workshop: Cut-offs and examples

The final workshop was held online on the 4th of July 2024. The mural used is shown in Figure 10. The left side of this Mural is a list of the practices evaluated during the first workshop. These practices were ranked based on their total score (the sum of the ratings across the 7 criteria). This ranking does not imply a hierarchy of quality among the practices but served as a tool for reflecting on the boundaries between effective and less-effective practices and select exemplary cases to present in this deliverable. Practices highlighted in orange are the ones that were not seen as STEAM during Exeter's workshop and thus deleted from our mapping.

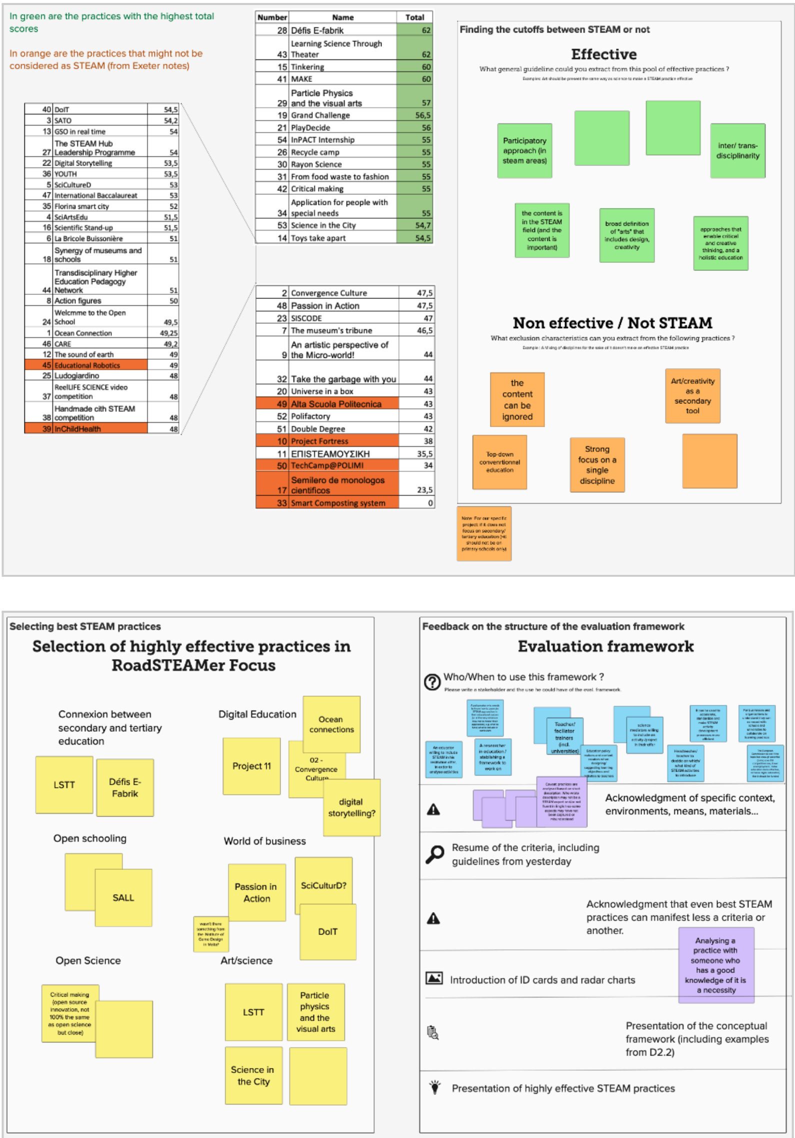

Figure 10: Mural produced after the final workshop of T4.4

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4.3.1 Effective and less-effective practices

Table 3 summarises the scores from the workshop and the rich discussions that took place. These guidelines are indicative rather than absolute; each practice should be considered individually, with attention to its context (environment, materials, resources, etc.) during any analysis.

Effective	Less-effective
- Including arts (in a broad sense, including fine arts, design, creativity) - Inter/trans/multi disciplinarity, with an equitable importance for sciences and arts (not using art as a secondary tool) - Enabling critical thinking and holistic education - Using participatory approaches - Addressing concrete subject, issue, challenge is a strong advantage	- Using art/creativity as a secondary tool - Strong focus on a single discipline or a mixing without relevance or connections between them - Top-down conventional education (if dealing with students) - One-way science communication

Table 3: Characteristics of effective and less-effective STEAM practices

The limited number of characteristics reflects the wide variety of practices and contexts, making it impractical to define strict boundaries. This diversity is also what enriches STEAM education.

4.3.2 Highly effective practices

We will now introduce examples of highly effective STEAM practices in RoadSTEAMer focus areas and their radar charts.

◊ **Digital education**

Global Game Jam NEXT is a global event organised by local hosts around the world. The game jam is intended for young creators aged 12-17 and the goal is to come together and make a game (videogame, board game, card game…). The duration of the event is 2 weeks, usually at the end of January each year. The first week is dedicated to game design and development workshops by experts in the field. During the 2nd week, the young participants form teams and work on their games, following a specific theme given by the central organising committee (e.g. “Inclusivity”). The young jammers come up with new ideas and make quick sketches of how they might work to prototype and playtest. The brief time span encourages creative thinking and innovative experimental games. Throughout the event, the young participants are supported by dedicated mentors. The radar chart of this practice is shown in Figure 11.

This practice allows participants to exercise significant creativity, both graphically and in designing game mechanisms, which is why it scored a 10 for this criterion. However, since only digital tools are integrated, the disciplinary inter-relationship is present but limited, resulting in a lower score for this criteria. Additionally, it was noted that few minorities benefit

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from specific inclusion policies, and the number of available slots, as well as the required materials and specialists, are limiting factors.

Figure 11: Radar chart of Global Game Jam NEXT

Digital Storytelling is an engaging and empowering activity for both learners and teachers, enabling them to tell and share stories about Climate Change. This process builds on the creative talents of learners, who will begin to research and tell their own stories, become fact-checkers using libraries and the Internet, and act as Community Reporters by analysing, synthesising, and sharing a wide range of content. Additionally, they will develop their communication skills by organising their ideas, asking questions, expressing opinions, and constructing narratives. Digital Storytelling appeals to learners with diverse learning styles and fosters collaboration, thereby enhancing the learning experience through a sense of ownership and accomplishment. The radar chart of this practice is shown in Figure 12.

Figure 12: Radar chart of Digital Storytelling

In this activity, the most notable aspect is its connection to the critical issue of climate change, anchoring it in a significant contemporary challenge. The various stages of personal

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reflection, in-depth research, and sharing are also noteworthy components. Additionally, the open access to methodology, resources, and inspiring examples makes the activity accessible despite the absence of a policy specifically oriented towards this objective.

The Ocean Connections project was an EU funded (Erasmus+) project to promote the teaching of ocean literacy using creative and digital pedagogies. Through student-centred, problem-based learning this project fostered the use of innovative material, dialogic and creative approaches to using AR/VR technologies. It used STEAM approaches to connect aquaria as informal learning centres with formal schooling, informed by research evidence. 6 projects were run within schools, teaching about different facets of ocean literacy and underpinned by educational principles developed from the project using a research base that connected STEAM creative pedagogies, science in society research, ocean literacy principles and research into effective use of digital technologies. The project took place in the UK, Spain and Denmark. The radar chart of this practice is shown in Figure 13.

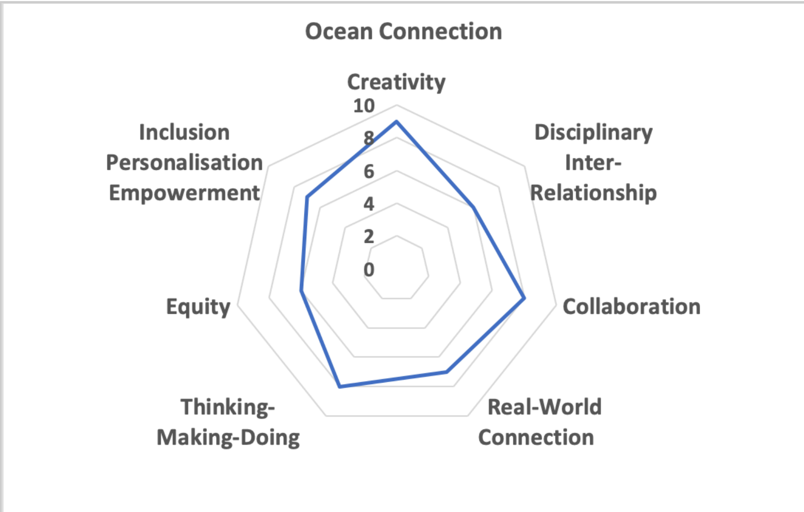

Figure 13: Radar Chart of Ocean Connection

In this project, students created virtual spaces by choosing what they wanted to highlight and how to do it, which led to a high score in creativity. Collaboration with specific external partners naturally resulted in a high score for collaboration. However, this also limits widespread implementation, as not all students have easy access to such structures. Despite making tools available online to reproduce the projects, the digital aspect also limits implementation in the absence of suitable equipment. This resulted in a relatively low score for equity.

The LeDS project – Learning Digital Skills through Arts and Performance – developed an innovative STEAM approach integrating arts to teach digital skills. Students and teachers from Portugal and Greece created digitally enhanced dance and aerial circus performances to promote STEAM and raise awareness about human and environmental diversity. The team produced a Digital Creations Toolkit for programming electronic solutions that react to environmental changes, using light, sound, and movement. With this toolkit, participants developed performances themed "A Universe of Difference," which they presented to their

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community. Through this approach, students gained essential digital, academic, social, and emotional skills, while teachers enhanced their digital and STEAM education skills. The final toolkit was made available for others to recreate the activities. The radar chart of this practice is shown in Figure 14.

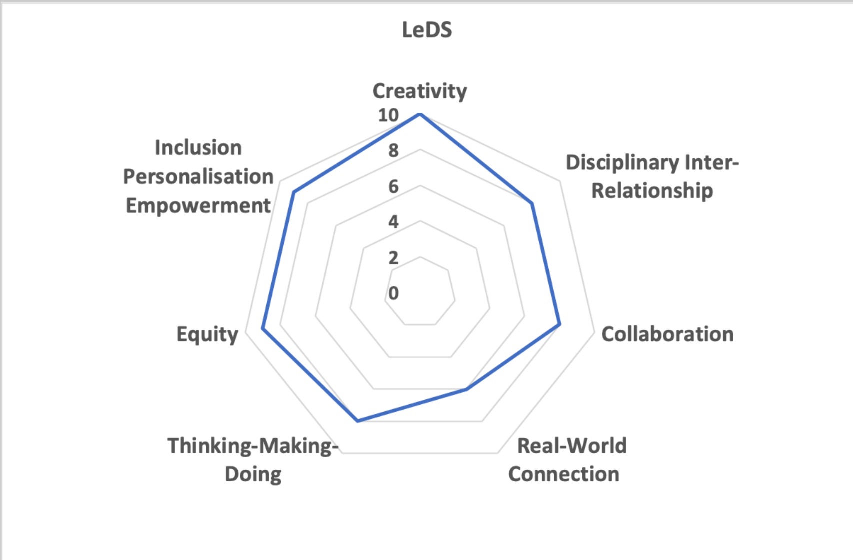

Figure 14: Radar chart of LeDS

In this activity, creativity scored the highest as it is its main component. Equity and inclusion also received high scores. Resources were made accessible, the various subjects seemed equally important, and students were creators, putting them on an equal footing with teachers, who had a comparable role. Additionally, the theme "A Universe of Difference" to raise awareness about diversity in nature and human development was very inclusive.

- ◊ **Art and science**

The community arts group In-Public (co-founded by Ian Andrews and Sarah Fortes Mayer) have been collaborating with the University of Birmingham particle physics group to develop a series of practical workshops for Primary and secondary schools. The workshops developed with Prof Kostas Nikolopoulos are designed to operate at different levels for different participants and explore the relationship between fine art and particle physics. The exercises explored in the workshops use artistic visualisation techniques to give visual form to particle characteristics and interactions to aid understanding and stimulate further interest. They utilise the interrelationship between drawing, photography, sculpture and performance and offer an "art school " experience for students, pupils and adults in addition to providing an introduction to particle physics. Additional workshops "particle cartoon characters" have been designed for primary school pupils 8 to 11 years old. Other workshops have been designed to explain the approach to educators and demonstrate the techniques to them as professional practice development. The radar chart of this practice is shown in Figure 15.

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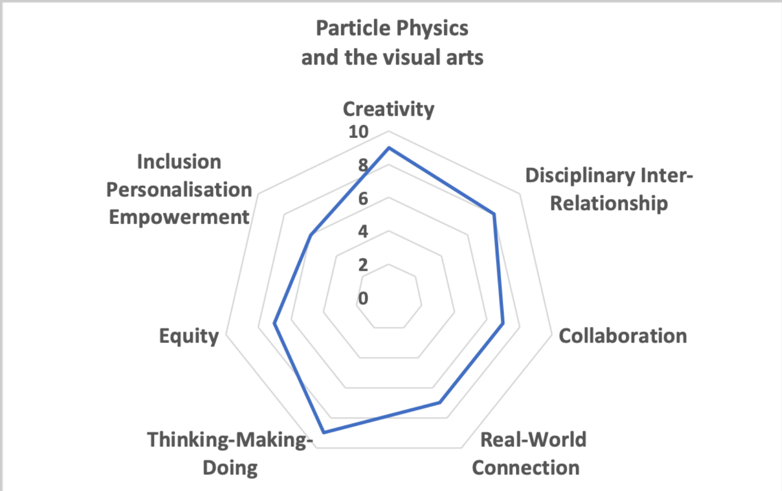

Figure 15: Radar chart of Particle Physics and the visual arts

The creative and Thinking-Making-Doing aspects of this practice are very strong, directly linking complex physics concepts with artistic notions and their simultaneous use to produce works. However, while no community is explicitly excluded, there is no policy in place to reach those less likely to participate. The workshop is accessible to only a small number of students because no resources are available as open access on its website, and the necessary materials are not easily accessible. However, it is important to note that exhibitions of the works produced are regularly organised to share it with a wider audience.

◊ **Open schooling**

SALL is a European project that developed a methodology inspired by the "Living Labs methodology" to enable students to build projects involving their local community, researchers, and businesses in solving concrete problems. The entire creation process is collaborative, empowering students by positioning them as change-makers. The radar chart of this practice is shown in Figure 16.

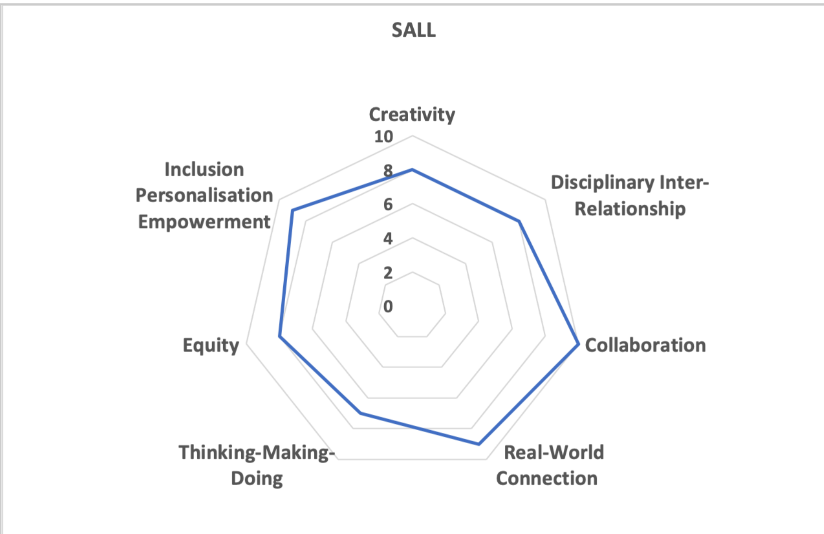

Figure 16: Radar chart of School As Living Lab

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The collaborative aspects, Inclusion/personalisation/empowerment and connection to the real world are evident and highlighted by the scores obtained. Interdisciplinary elements are possible but depend on each project's development, as does artistic creativity. In this practice equity can be seen at different levels: teachers are positioned as equal participants as students, every community can use the methodology which is freely available online, challenges targeted can be social justice issues if the participants choose it.

◊ World of business

DoIT stands for Digital Fabrication and Making for Social Innovators. The project's primary goal was to create and evaluate an innovative Social Innovation and Entrepreneurship Education Programme for children and educators. This program integrated digital making education and open innovation methods, leveraging technology to instil sustainable innovation practices in social and traditional businesses. Targeting young learners (6 to 10 years), older pupils (11 to 16 years), and educators, the DOIT toolboxes facilitated experiential learning in child-friendly maker spaces. These resources, available on the DOIT Web platform, covered aspects of inspirational experimentation, design, prototyping, and basic business modelling for sustainable product and service innovation. The project conducted extensive testing and validation across European countries, collaborating with regional innovation labs, schools, and business networks on various topics. The radar chart of this practice is shown in Figure 17.

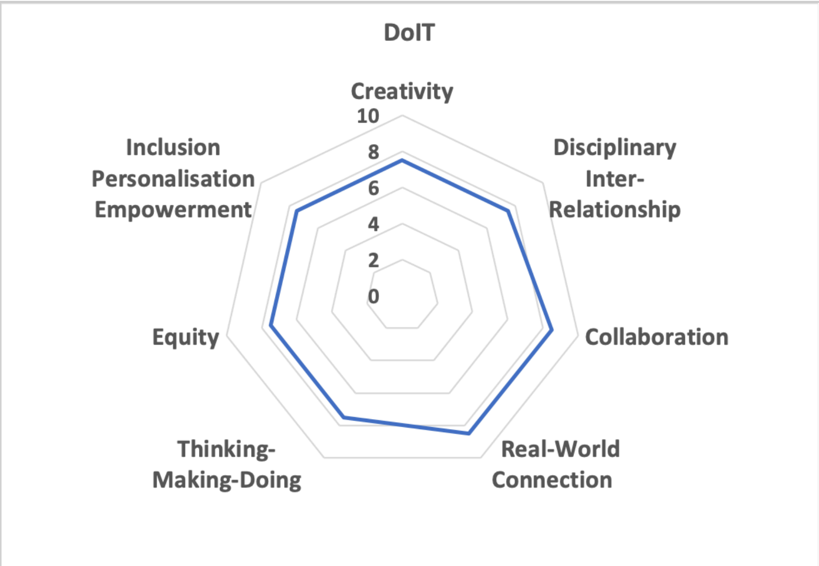

Figure 17: Radar chart of DoIT

This practice stands out for its strong entrepreneurial focus and its grounding in real-world issues, as students are encouraged to address concrete problems related to their environment. The DOIT project fosters entrepreneurial thinking, social innovation, and collaborative, interdisciplinary work. Additionally, policies are implemented to reach a broad range of minorities, resulting in relatively high scores across all criteria.

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◊ **Open science**

The Critical making project adds scientific insights into the potential of the maker movement. Focusing on critical and socially responsible making in Fablabs, maker spaces, etc., to promote responsible research & innovation within them. It shows how global maker communities can offer new opportunities for young talents of all genders to contribute to an open society via open source innovation. It provides hands-on inputs for practitioners, enriching scientific knowledge in the RRI community focused on innovation practices. The radar chart of this practice is shown in Figure 18.

Figure 18: Radar chart of Critical making

This practice received very high scores in creativity, disciplinary interrelationship, and thinking-doing-making due to its approach, the possible integration of various scientific fields, and its alignment with the "maker movement," which encourages students to learn, experiment, and share through innovation. However, the requirement of having access to a fab lab limits its accessibility, resulting in a lower score for equity.

◊ **Secondary and tertiary education frontier**

In LSTT (Learning Science Through Theatre), students innovate, create, and learn by dramatising scientific concepts. This initiative promotes Science Communication & Education by connecting the school with the local and research communities through an innovative and creative approach. Students from all grades (primary & secondary) dramatise scientific notions from their curriculum to provide solutions or motivate the community in an interdisciplinary approach. LSTT is centred around the STEAM IDEAS' Square (SIS), a facility based on the Design Thinking Approach, serving as a meeting place for science, art, and society. SIS aims to generate ideas and address societal needs by exploring and imagining novel solutions. These solutions are created within the school and shared with the community. The radar chart of this practice is shown in Figure 19.

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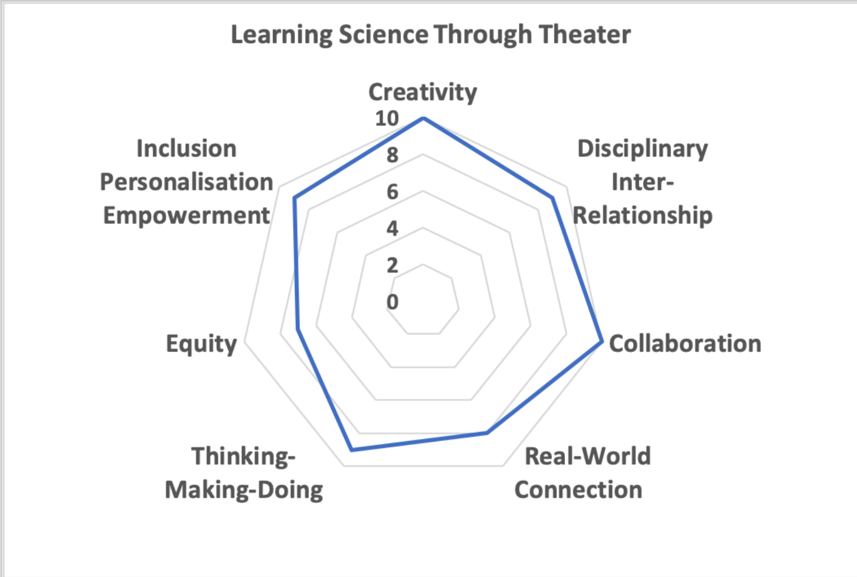

Figure 19: Radar chart of Learning Science Through Theatre

LSTT bridges secondary and tertiary education by facilitating exchanges between academics and students. The maximum score in creativity is due to the integration of theatre and science, allowing participants to gain knowledge in both fields as well as soft skills. However, the low score in equity can be attributed to the difficulty of replicating this initiative without being part of the project, as the resources required to start from scratch are substantial.

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5. Conclusion

The feedback from the first workshop highlighted the general appropriateness and relevance of the 7 criteria for evaluating STEAM practices. While there was some concern about the potential excess of criteria, it was acknowledged that not all criteria need to be applicable to every practice. These results are in line with the findings of Real-life use cases workshops on this matter : the criteria offer an accurate picture of practices; however, the prevalence of one or more of them depends on the approaches and methodologies adopted.

Another concern was the subjectivity of evaluators. To mitigate it, the honesty of participants and evaluators, alongside collective scoring, were seen as essential.

The need for a clear introduction and detailed explanation of each criteria was emphasised to enhance understanding and application. Examples of high and low scores detailed in part 4.2 of this report were seen as necessary additional guidelines. Establishing "cut-offs" points for defining effective STEAM practices was also recommended and is detailed in part 4.3 along with exemplary practices in various areas of interest.

Finally, having knowledgeable individuals present during any analysis is essential.

To summarise, the evaluation framework comprises various tools for a thorough analysis of STEAM practices:

- A set of rigorous and relevant criteria enabling a common analysis of diverse practices.
- Guidelines illustrating the highest and lowest scores for each criterion, along with a clear and simple representation of the obtained scores.
- Four conceptual approaches, allowing for nuanced study of practices while considering their specific contexts and objectives.
- Cut-offs characteristics that help initially validate or exclude certain practices.
- A series of exemplary cases across various domains.
- A comprehensive mapping of numerous practices, serving as a rich source of inspiration.

The evaluation framework developed during the RoadSTEAMer project offers substantial utility to a wide range of societal actors such as:

- **Policymakers**:
    - **Promotion of STEAM Approaches**: Policymakers can use the framework to direct funding towards effective STEAM practices, potentially reshaping the school curriculum to incorporate practices with the identified criteria and characteristics.
    - **Objective Setting**: It can aid in formulating objectives that integrate effective STEAM practices, ensuring that educational goals align with promoting innovation and critical thinking.

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- **Educators**:
  - **Inclusion of STEAM Approaches**: Educators looking to integrate STEAM into their institutions can use the framework to assess the effectiveness of different activities and select appropriate activities.
  - **Inspiration**: The accompanying map presents a wide range of practices that can serve as a rich source of inspiration.
- **Researchers in Education**:
  - **Rigorous Criteria**: Researchers can rely on the well-defined criteria of the framework for their studies, ensuring their work is grounded in a robust evaluative structure.
- **Formal Education**:
  - **Inspiration for Teachers and Headteachers**: The framework can inspire teachers and headteachers in the formal education sector to create or adapt activities that meet high standards of STEAM education.

The RoadSTEAMer evaluation framework can accelerate the development of effective STEAM activities through various channels. By leveraging this framework and the roadmap that will emerge from our project, we hope that policymakers can make strategic decisions that foster innovation and enhance educational outcomes across Europe.

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ANNEX 1

Practice ID card

Name of the practice

Website

Collaborating with:
School / Universities / Businesses
Other: ………………………..

Format:
Open Schooling/Open Science – Scale

Description:

Socioeconomic aspects

Inclusion policy to reach specific groups of people	Addressing social challenges	Potential barriers to join the activity
◻ All genders ◻ Teenagers/young adults from less privileged or disadvantaged households ◻ Teenagers/young adults from minority cultural backgrounds ◻ Teenagers/young adults from rural areas ◻ Teenagers/young adults in your neighbourhood or community ◻ Teenagers/young adults with special education needs ◻ Teenagers/young adults with disabilities ◻ LGBTQ+ persons ◻ Migrants from outside the EU, refugees, asylum seekers	◻ Future employment (skills in high demand in the current job market) ◻ Social justice (transforming unfair and violent social orders through minority's awareness and mobilisation) ◻ Gender's equity improvement ◻ Knowledge hierarchy (Increasing self-empowerment / confidence for people with low educational background) ◻ Racism ◻ Sexism ◻ Mental health and wellbeing ◻ Climate neutrality / sustainability	◻ Accessibility of the venue (Geographic location / Mobility / Reputation) ◻ Activity not promoted sufficiently ◻ Cost (including participation fee, materials, etc) ◻ Not receiving accreditation (e.g. credits or certificate) ◻ Number of places available ◻ Scheduled time of activity ◻ Untrained staff / protocols for those with special educational needs and/or disabilities

Need of background knowledge: **Yes/No**

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Criterias

Collaboration	Disciplinary Inter Relationships	Thinking-Making-Doing	Creativity	Real-world Connection	Inclusion, Personalisation, Empowerment
Collab. between participants: /100 **Tools to facilitate collab.:** Technology, Game-based learning, DIY learning, Communication Artistic practice, Creative practice, The environment **The facilitator is considered as:** Equal with the participants, Advisor, Guide, Top-down ed.	**Are the disciplines involved of equal importance:** /100 **Disciplinary inter-relationship:** Multidisciplinarity, Interdisciplinarity, Transdisciplinarity **Disciplines involved** (open-ended answer) **Roles of the arts:** Developing understanding/learning in the arts/STEM, Contributing understanding/learning of creativity/design thinking/aesthetics, Integrating with STEM to respond to a problem, Encouraging social/cultural/emotional development, Broadening the skills and mindset of participants	**Competencies used by the participants:** Critical learning, Problem solving, Active behaviour, Observational skills, Object-based learning, Uncertainty management, Connection with their environment **Balance between T/M/D:** Equal emphasis to all three throughout the activity, Prioritising thinking aspect gradually integrating hands-on/practical applications, Emphasising making/doing aspect minimising thinking, Allowing flexibility between the three, Separating TDM aspects in dedicated phases	**Utility of participants creativity/creative thinking:** /100 **Tools enabling collab:** Artistic practice, Creative practice **Creativity is linked to:** Innovation, Playfulness, TMD, Interdisciplinary connections, Collaborative support	**Related to a concrete problem:** Yes/No **It employs (skills):** Technological skills, Entrepreneurship skills, Interdisciplinary skills, Personal development **Participants competencies involved:** Critical learning, Problem solving, Active behaviour, Observational skills, Object-based learning, Uncertainty management, Connection with their environment **Participants develop their:** Interest for socio-economic knowledge, Career aspiration	**Level of accessibility:** /100 **Scientific background needed:** Yes/No **Roles of the arts:** • Encouraging social/cultural/emotional development, • Increasing self-expression, self-esteem and wellbeing, • Broadening the skills and mindset of participants. **Participants develop their:** Personal development, Self-empowerment, Self-confidence, Personal meaning expression

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